



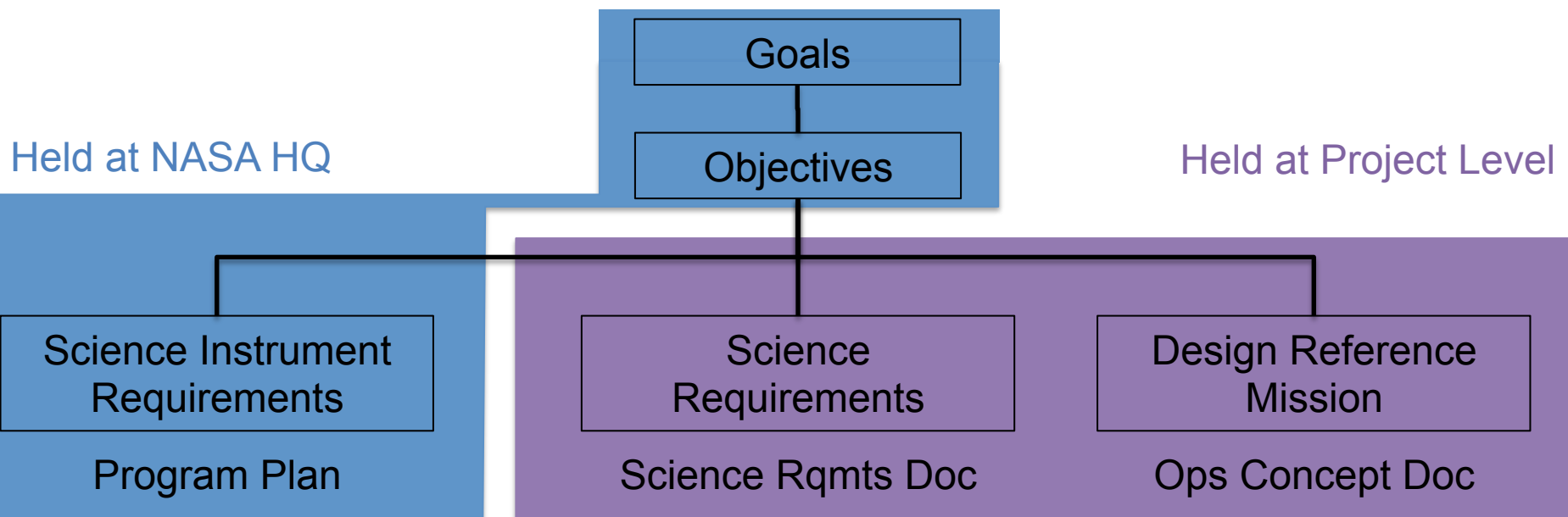
# Level 1 Requirements & Ops Concept

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## Level 1 Requirements Progress

- Since the last SDT meeting, I received updates from SDT members in response to previous HQ comments/questions. Reviewed them internal to the Project and with HQ and made a few edits to keep them consistent with HQ needs.
- REMINDER: At Level 1, HQ would like requirements that:
  - Are written at a high enough level to provide the Study Office with flexibility in design trades underlying them
  - Are written so that the designed mission can produce test data on the ground that can be vetted quantitatively against the requirement
  - Feature in only one BSR; aggregated instrument requirements from all science cases can flow into them.

# WFIRST Top Level Science Requirements



The WFIRST Top Level Science Requirements are captured in two locations. The Program Plan contains the Science Objectives and the Science Instrument Requirements and is maintained at NASA HQ. The Science Requirements Document captures the Science Requirements and contains the detailed description of the flowdown from the Science Objectives to both the Science Instrument Requirements and the Science Requirements. Together, the Science Instrument Requirements, the Science Requirements, and the Design Reference Mission work to validate the WFIRST mission will meet the Science Objectives outlined in the Program Plan.

# Dark Energy Goals & Objectives

- Goal
  - WFIRST will characterize the history of cosmic acceleration and structure growth, with the goal of answering two fundamental questions about the origin of acceleration
    - Is acceleration caused by a new energy component or by a breakdown of general relativity on cosmological scales?
    - If the cause is a new energy component, has its energy density been constant in time or evolving over the history of the universe?
- Survey Envisioned
  - WFIRST seeks to measure the spectra, light curves, fluxes, and redshifts of 2000 Type Ia supernovae over the redshift range of  $z = 0.2$  to 1.7 in the supernova survey, the positions and redshifts of 20 million emission line galaxies in the redshift range of  $z = 1 - 2$  in the galaxy redshift survey, and the shapes and redshifts of 500 million galaxies in the redshift range of  $z = 0 - 2$  in the weak lensing imaging survey.
- Objectives
  - Measure the expansion history of the Universe with sub-percent precision over the redshift range  $z = 0$  to 2 by combining three or more measurement techniques (BAO, SNIa and WL) to provide coverage and **high-precision cross-checks** across the full redshift range.
  - Measure growth of structure with sub-percent precision over the redshift range  $z = 0$  to 2 combining at least 2 techniques (WL, RSD **or clustering**) to provide coverage **and high-precision cross-checks** across the full redshift range.



## Dark Energy Requirements

- **BSR1:** WFIRST Wide-Field Instrument (WFI) shall measure positions and redshifts of emission-line galaxies in the redshift range  $z = 1 - 2$  with a position accuracy of TBD and a redshift accuracy of 1 part in 1000 and a minimum detectable point-source line flux of  $0.5 \times 10^{-16}$  ergs/cm<sup>2</sup>/s at  $7\sigma$  significance in the high-latitude **spectroscopic** survey.
- **BSR2:** WFIRST WFI shall measure shapes of galaxies at  $z=0-2$  in at least 2 bands, and fluxes in at least 4 bands for photometric redshifts, **at a depth equivalent to a 5-sigma point source detection at** AB magnitude  $J < 26.9$  or  $H < 26.7$ , with photometric accuracy of TBD and rms uncertainties (in the shape measurement filters only) below  $10^{-3}$  in the PSF second moment and below  $5 \times 10^{-4}$  in the PSF ellipticity, **in the high-latitude imaging survey**.
- **BSR3:** WFIRST WFI shall measure the spectra, light curves, fluxes, and redshifts of Type Ia supernovae with 5 day cadence over a redshift range of  $z = 0.2$  to  $1.7$  with rms measurement errors of  $\leq 0.08$  mag per supernova from IFU spectrophotometry in synthetic bandpasses and systematic calibration uncertainties of  $\leq 0.01 \times (1+z)/1.8$  mag for the mean flux in each  $\Delta z = 0.1$  redshift bin.

# Exoplanet Microlensing Goals & Objectives

- Goal
  - The goal of the WFIRST exoplanet microlensing survey is to understand how planetary systems form and evolve and to determine the prevalence of planets in the colder, outer regions of planetary systems where habitable worlds are found.
- Survey Envisioned
  - WFIRST seeks to monitor a large number of systems for exoplanets, providing a yield for reasonable assumptions about planet frequency of at least 3000 planets with mass above 0.1 Earth masses and semi-major axes greater than 1 AU, with at least 10% of these planets having the mass of the Earth or less. WFIRST also seeks to derive host star masses for at least half of the detected planetary systems.
- Objective
  - Complete the statistical census of planetary systems in the Galaxy, from the outer habitable zone to free floating planets, including analogs to all of the planets in our Solar System with the mass of Mars or greater.

## Exoplanet Microlensing Requirements

- **BSR4:** WFIRST WFI shall monitor **microlensing events toward the Galactic Bulge** in a primary filter with a cadence of  $\leq 15$  minutes, achieving a  $S/N \geq 100$  per exposure for a  $J_{AB} = 21.3$  star, and in a second filter with a cadence of  $\leq 12$  hours, **over seasons of no less than 60 days**.
- **BSR5:** WFIRST WFI shall have an angular resolution  $> 0.4$  arcsec.

# Exoplanet Direct Imaging Goals & Objectives

- Goal
  - The goal of the WFIRST exoplanet direct-imaging survey is to understand the compositions and atmospheric constituents of a variety of planets around nearby stars and to determine the properties of debris disks around nearby stars in order to understand how planets interact with these debris disks.
- Survey Envisioned
  - WFIRST seeks to characterize photometrically at least a dozen known radial velocity planets of at least 4 (TBR) Earth radii with minimum star-planet separations of TBD, to characterize half of these spectroscopically, and to search for other planets around nearby ( $\sim 10$  pc) stars. Additionally, WFIRST aims to search for low surface density circumstellar disks around several dozen nearby stars and to image the inner regions of known bright disks.
- Objective
  - Discover new planets and disks around nearby stars and characterize these new and previously known planets and disks by means of high-contrast imaging and spectroscopy. Develop coronagraph technology to enable this science and as an investment for future missions.



## Exoplanet Direct Imaging Requirements

- **BSR6:** WFIRST Coronagraph shall directly image exoplanets around nearby stars, and carry out color photometry measurements in the spectral range about 400-1000 nm, with effective contrast of  $3 \times 10^{-9}$  and an inner working angle of 200 milliarcsec after post-processing.
  - Open questions: Is this contrast at the IWA? At what wavelength is the IWA?
- **BSR7:** WFIRST Coronagraph shall spectroscopically characterize exoplanets by measuring continua and spectral absorption features over a wavelength range of 600 – 950 nm with mean spectral resolution of at least 70.
- **BSR8:** WFIRST shall be capable of making imaging observations of disks and planets in 2 orthogonal polarizations.

## Guest Observer Goals & Objectives

- Goal
  - WFIRST will have a robust Guest Observer program for wide-ranging astrophysical investigations using the wide field and coronagraph instruments.
- Objective
  - A substantial fraction of the WFIRST mission lifetime will be dedicated to a peer-reviewed Guest Observer program. This program will allow for a broad range of scientific studies of astrophysical targets in our Galaxy and external galaxies, to be observed over the full sky and at an adequate frequency through each year of the mission lifetime.

## Forward Path

- I believe we are at the point where we have a good set of placeholder requirements that meet the hardware based guidelines HQ asked us to develop and we can now focus on the detailed flowdown of the Level 2 requirements from this document. We need the SDT to review the latest draft and provide feedback on the requirements and the comments from HQ.
- The Program Plan will not be signed at headquarters for a couple of years so it's seems the best use of the SDT's expertise is to focus now on the detailed requirements development and flowdown at Level 2. We will certainly revisit the Program Plan requirements and objectives in the future.

## Operations Concept

- Initial operations concept overview has been assembled to document the current plan in a single location.
- The current draft was emailed last week and is posted on the SDT website with the materials for this meeting.
- HLS is a good example of where we are trying to get.
- Looking for inputs on
  - Observing scenarios, mapping strategy, dither strategy, pointing accuracy, data latencies
- Propose to work this along with the Level 2 requirements development.